Space Weather Technical Forecast

Issued on Friday 20 December 2024 at 13:02 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: M-class flares likely (R1-R2; Minor-Moderate Radio Blackouts) throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity is Moderate with four M-class flares which all appear to be from AR3927 or AR3928 in the southeast, with a peak flare of M3.8 at 19/1534UTC. There are currently ten sunspots visible on the Earth-facing disc, comprising of six numbered regions and four unnumbered. AR3924, previously the largest and most complex region, is now harder to analyse as it is close to the western limb and is due to rotate off disc soon. AR3922, the second-largest region, has recently developed intermediate spots. AR3927 has been divided into two distinct areas: the northern section retains the designation AR3927, while the southern spots are now classified as AR3928. Both regions have shown slight development in the past few hours and will be closely monitored as they rotate further onto the visible disc. A new and currently unnumbered region is following on behind AR3928 in the southeast, although this is difficult to analyse at present due to foreshortening effect. The remaining regions on the disc are smaller and appear magnetically simple.

Solar Wind / Geomagnetic Activity: Solar winds, observed at L1, have been at elevated to slightly elevated levels, with a peak of 520km/s observed by ACE at 20/1000 UTC. Density was mostly below average. The Interplanetary Magnetic Field (IMF), Bt, remained weak, around 4-8nT throughout. The north-south component, Bz, fluctuated between -7nt and +7nT. The phi angle was predominantly negative (towards the Sun). The resulting geomagnetic activity was mostly Quiet to Unsettled (Kp1-3), with a provisional Active interval (Kp4) observed at 20/0000-0300 UTC.

Energetic Particles / Solar Radiation: High energy proton flux observed by GOES18 was at background levels. High energy electron flux (greater than 2MeV) observed by GOES16 was background, with a diurnal peak into Moderate levels. The associated 24-hour fluence was below the Active (1e8 integrated flux) threshold. The 20/0000 UTC observation was 1.1e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate solar activity is forecast with further M-class flares likely, mainly from AR3927, AR3928, or any new regions from over the eastern limb. Slight chance of isolated X-class flares is maintained throughout.

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Solar Wind / Geomagnetic Activity: Solar winds have now reduced to slightly elevated levels and are expected to gradually decline to background conditions over the next few days. Geomagnetic activity is expected to be Quiet to Unsettled (Kp1-3) throughout, with Active (Kp4) intervals unlikely.

Energetic Particles / Solar Radiation: High energy proton flux is expected to remain at background, but carries a slight chance of reaching S1/Minor Storm levels, in response to any notable solar flares. High energy electron flux is likely to reach moderate levels at times with diurnal peaks reaching the high threshold. However, the 24-hour fluence is expected to remain below the Active threshold throughout.

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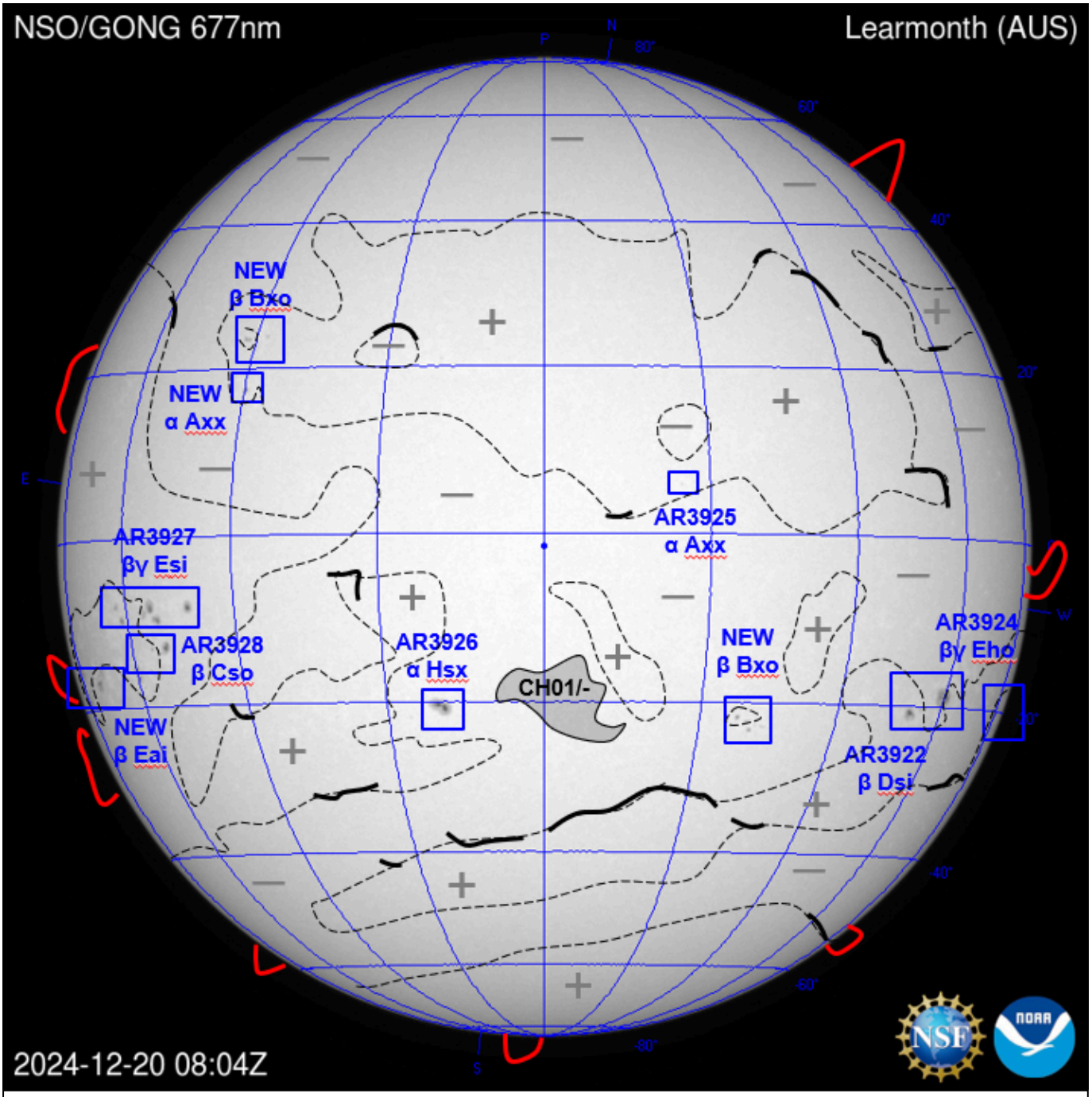
Figure 1: Solar analysis map - valid 20/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

Solar winds have now reduced into Slightly Elevated levels and a gradual decline is anticipated over the next few days to background conditions. Any previous estimations of CME arrivals are likely to have been swept up and are no longer forecast to have any impact on Earth, although this is perhaps the main source of uncertainty in the forecast.

A very fast halo CME was evident in LASCO imagery around 17/1600 UTC and a further around 19/1700 UTC, however these both appear with good confidence to be far-sided with minimal impact to Earth. There have been no further significant CMEs observed in the Earth-Sun line. A small coronal hole, CH01-, has developed near centre disc, this doesn't appear to be a particularly persistent feature and any connection to the HSS from it, is likely to be towards the end of the current forecast period and most likely rather weak given it's size and the proximity to the winter solstice. Geomagnetic activity is expected to be Quiet to Unsettled (Kp1-3) throughout, with Active (Kp4) intervals unlikely.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	5	5	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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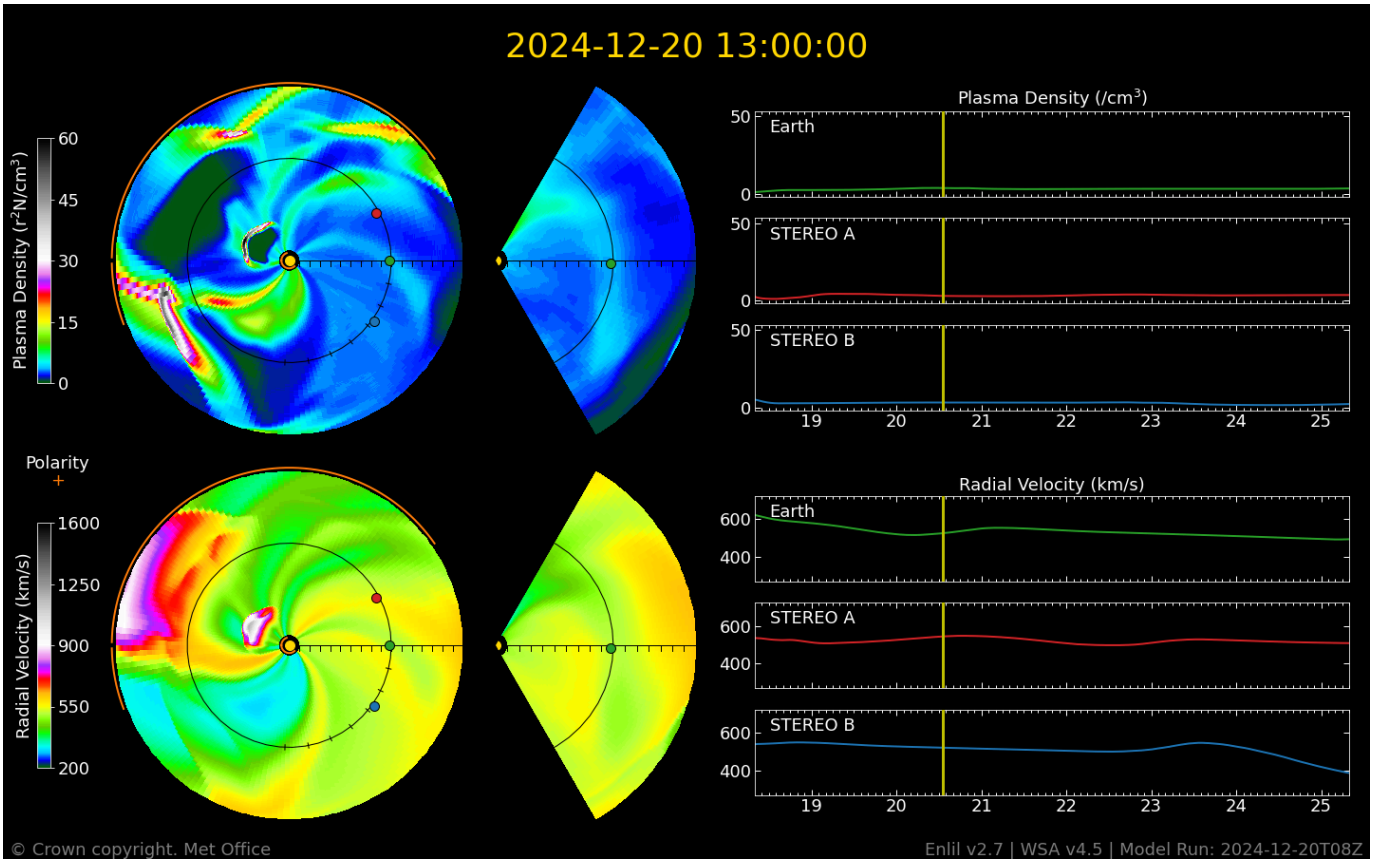
Figure 2: MOSWOC Enlil model.



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Radio Blackouts - X-Ray Flares

There are currently ten sunspots on the visible disc, comprising of six numbered regions with four unnumbered. AR3924, previously the largest and most complex region, is now harder to analyse as it is close to the western limb and is due to rotate off disc soon. AR3922, the second-largest region, has recently developed intermediate spots. AR3927 has been divided into two distinct areas: the northern section retains the designation AR3927, while the southern spots are now classified as AR3928. Both regions have shown slight development in the past few hours and will be closely monitored as they rotate further onto the visible disc. A new and currently unnumbered region is following on behind AR3928 in the southeast, although this is difficult to analyse at present due to foreshortening effect. The remaining regions on the disc are smaller and appear magnetically simple.

Solar activity is now at Moderate levels following the four recent M-class flares, two of which were from AR3927 or AR3928 near the eastern limb. The emergence of further sunspot regions expected to rotate onto the disc from over the east limb over the next few days increases the chances of M-class flares with time as shown in the table below. These regions perhaps corresponding to Ex-AR3905 and Ex-AR3906. These regions have a history of generating M-class flares when they were last on the Earth-facing side of the solar disc. Recent far-sided CME activity and helio-seismic soundings suggest that at least one of these regions remains active.

Moderate solar activity is expected to continue with further M-class flares likely, mainly from AR3927, AR3928, or any new regions from over the eastern limb. Slight chance of isolated X-class flares is maintained throughout.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	60	60	65	70
Very Active	R3-R5 (X Class)	No	10	10	10	10

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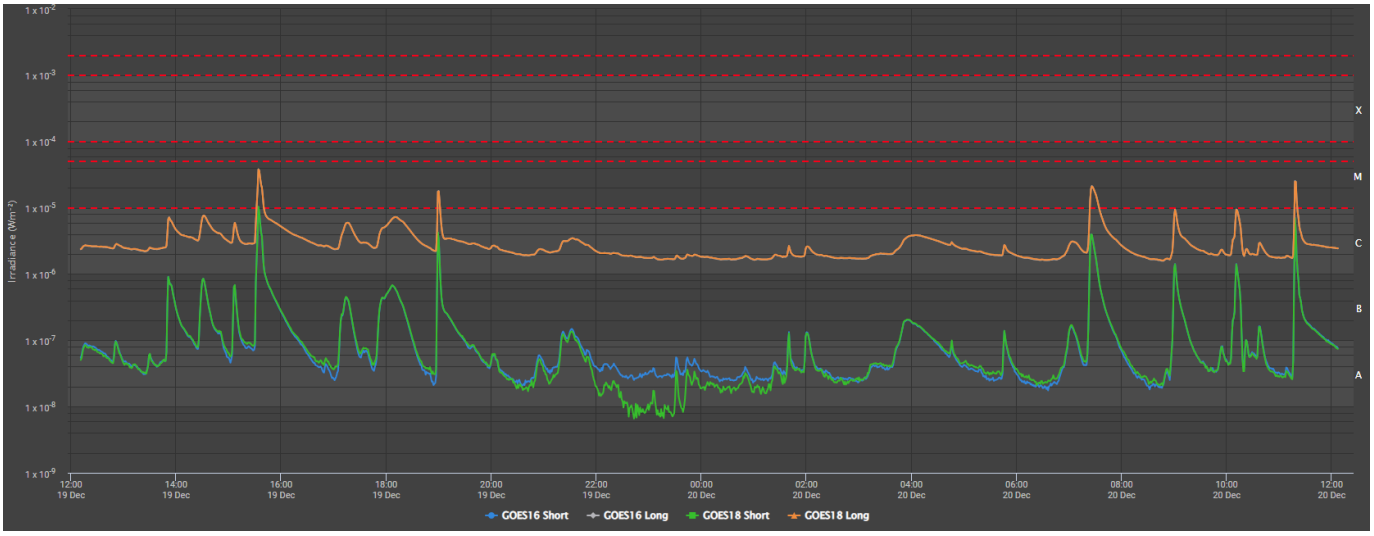
Figure 3: GOES-16/18 X-Ray flux trace.



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Solar Radiation Storms (High Energy Protons)

AT GEO the GOES18 proton flux is at background levels. There is a continuing slight chance of reaching S1/Minor Storm levels, in response to any notable solar flares, currently most likely from AR3924 and AR3922. AR3924 will likely rotate over the western horizon on Day 1 (20 Dec), shortly followed by AR3922, but proton storm probabilities are maintained after it leaves the visible disc. In the meantime, other complex regions will remain in the eastern hemisphere for the forecast period.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	15	15	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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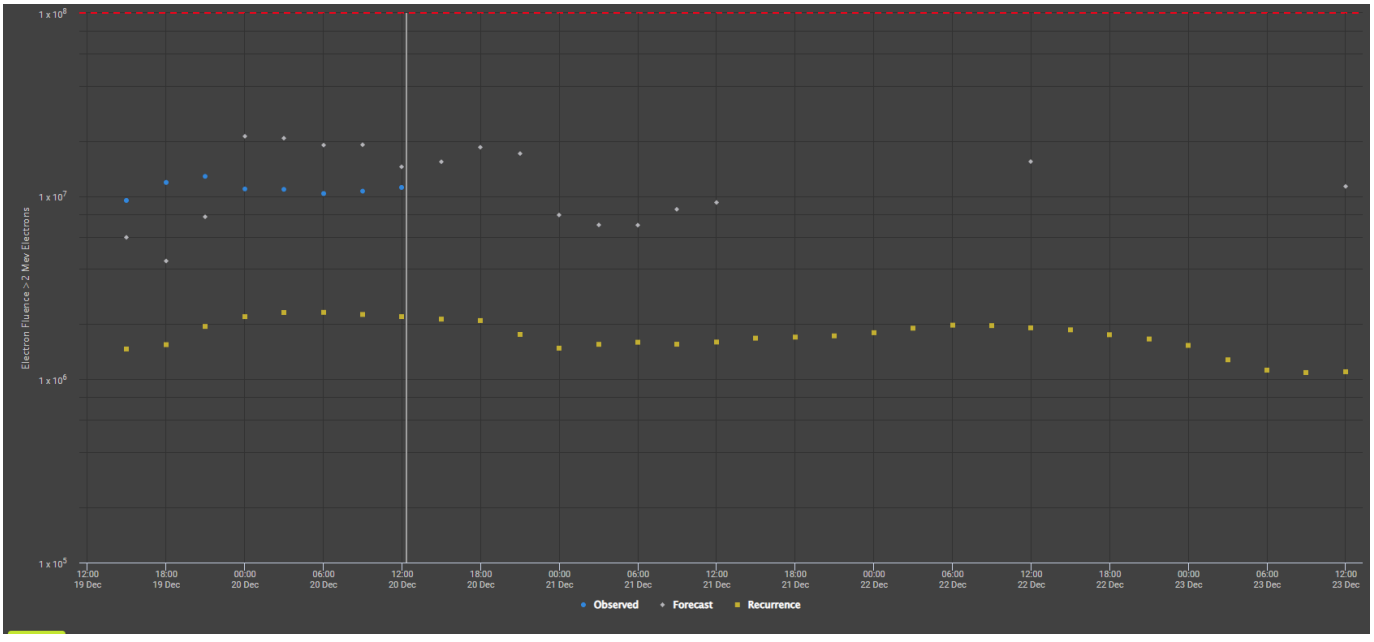
High Energy Electrons (≥ 2MeV)

High energy electron flux observed by GOES16 has been at background levels, diurnally rising to Moderate following the influence of the recent CME arrival on 17 Dec. The CME likely caused the electron belts to become compressed away from GEO. However, as the CME influence wanes the Van Allen belt will continue to relax and expand back towards GEO in coming days. As a result, the electron flux at GEO may peak at high levels within the diurnal cycle.

The associated 24-hour fluence will increase in response but is likely to remain below the Active (1e8 integrated flux) threshold until the end of the period. MOSWOC REFM output is considered to be providing good guidance in this aspect.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	5	5	10	20
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

Figure 4: MOSWOC electron fluence.



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